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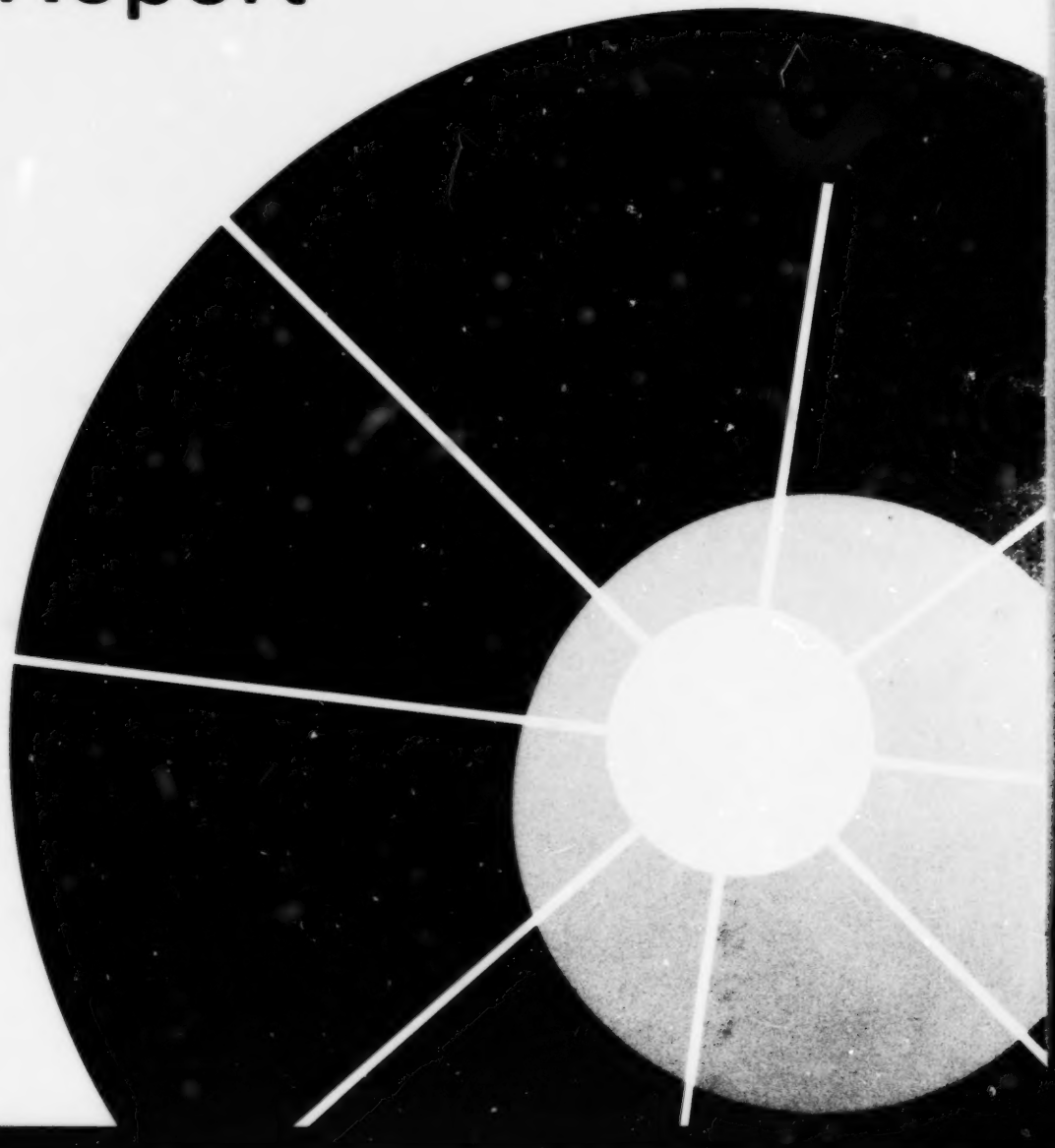
Canada - Saskatchewan Renewables — Conservation Demonstration Program

Final Report



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CANADA-SASKATCHEWAN CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

On March 18, 1980, the governments of Canada and Saskatchewan entered into a Conservation and Renewable Energy Demonstration Agreement. The Agreement, which terminates March 31, 1984, funds the development and demonstration of a wide range of conservation and renewable energy technologies. The program is funded on an equal cost-shared basis by Canada and Saskatchewan, and is administered by Saskatchewan.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies which exploit renewable energy resources, conserve energy, or make its use more efficient;
- To create employment in new or existing industries;
- To develop broad public awareness of the potential of renewable energy and energy conservation technologies.

This report outlines the results of a project funded by the Government of Saskatchewan as represented by Saskatchewan Energy and Mines, and the Government of Canada as represented by Energy, Mines and Resources Canada, under the terms of the Renewables-Conservation Demonstration Program, and contracted with the party identified herein.

However, neither the Government of Saskatchewan as represented by Saskatchewan Energy and Mines, nor the Government of Canada as represented by Energy, Mines and Resources Canada, accept liability for any errors, omissions, or inaccuracies that may; be included in or derived from this report, nor do they assume any liability with respect to the use of, or actions resulting from the use of, any information contained in this report.

S45 K. 35

Retrofit: North Battleford Civic Centre

Retrofit of Recreation Facilities Project — Phase II

Final Technical Report
on a Renewables-Conservation Demonstration Program Project

Conducted By

Saskatchewan Culture and Recreation
and the City of North Battleford

And Supported By

Saskatchewan Energy and Mines
and
Energy Mines and Resources Canada

Project Leader: Cecil Nobes

Miscellaneous
Report FP-39

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* See Overview Report

1. INTRODUCTION

1.1 Scope of Work

In the fall of 1983 Saskmont Engineering Ltd. was commissioned to implement Phase II of a retrofit on the North Battleford Civic Centre.

Phase II follows the Phase I energy audit of the building which culminated in the Source Report "North Battleford Civic Centre -- Energy Audit by Saskmont Engineering Ltd. dated August 1982".

The recommendations contained in the Phase I audit were analyzed by a committee of the City of North Battleford, Saskatchewan - Culture & Recreation, Saskatchewan Energy & Mines, and Energy Mines and Resources Canada. Several measures were selected for implementation in the building.

1.2 Overview of the Ice Arena

The Civic Centre was built around 1961 and consists of 49,000 square feet of skating surface, bleachers, lobbies and lounges.

The ice plant is an ammonia brine system. The building's primary heating is through a steam boiler. Heat is distributed through three air handling systems.

The building has historically used about 61 EKWH/SF/year.

1.3 Summary of the Source Report

The Phase I report prepared by Saskmont Engineering Ltd. contained the following energy conservation opportunities (note: N/C means no cost and N/R means not reported):

Item	Description	Capital Cost	Annual Savings	Payback Period	Remarks
1	Cycle DHW circulation pump (P-2).	N/C	$ 29	immediate	Measure a
2	Reduce DHW temperature.	N/C	$ 36	immediate	Measure b
3	Reduce room temperature.	N/C	N/R	immediate	Measure c
4	Isolate gas-fired DHW heater in winter	N/C	$ 5	immediate	Measure d
5	Keep ambulance room window closed	N/C	$ 2	immediate	Measure e
6	Caulk south wall under soffits.	$ 50	$ 160	0.3 yrs.	Measure f
7	Cycle brine pump (P-7).	$ 1,000	$ 1,004	1.0 yrs.	Measure 1
8	Descale evaporative condenser (CT-1)	$ 400	N/R	N/R	Measure g
9	Replace access cover on lounge ventilation unit.	N/R	N/R	N/R	Measure h
10	Install a demand control system.	$ 1,500	$ 1,000	1.5 years	

1. INTRODUCTION - continued

1.3 Summary of the Source Report - continued

Item	Description	Capital Cost	Annual Savings	Payback Period	Remarks
11	Install time clock on parking lot lighting.	$ 500	$ 240	2.0 years	
12	Repair exhaust fan dampers.	N/R	N/R	N/R	Measure i
13	Insulate steam piping.	$ 3,500	$ 867	4.1 years	Measure 2
14	Change corridor lights to higher efficient fluorescent.	50¢	11¢	4.5 years	Per lamp Measure j
15	Add control valves and thermostats to uncontrolled radiation.	$ 900	$ 186	4.8 years	Measure 5
16	Repair unit heater in S.W. corner change room.	N/R	N/R	N/R	
17	Repair leaking plumbing fixtures	N/R	N/R	N/R	
18	Weatherstrip emergency doors.	$ 700	$ 120	5.8 years	
19	Change lighting over bleachers.	$ 3,500	$ 389	9.0 years	Measure 3
20	Weatherstrip front doors.	$ 500	$ 68	7.4 years	
21	Repair rink service door.	$ 3,000	$ 390	7.7 years	
22	Recover ice machine waste heat.	$ 2,000	$ 220	9.1 years	Measure 4
23	Insulate rink with glazing.	$10,000	$ 1,070	9.3 years	
24	Modify lounge ventilation system.				
	.1 Re-label day/night switch	N/C			Measure 6
	.2 Relief louvre and R.A. fan.	$ 3,000			Measure 6
	.3 Low leakage damper.	$ 1,000			Measure 6
	.4 Relocate air-conditioning controller.	$ 500			Measure 6
	.5 Interlock washroom exhaust.	$ 300			Measure 11
	.6 Provide 8 hours run time.	$ 400			Measure 6
	SUB-TOTAL Item 24	$ 4,900	$ 517	9.5 years	

1. INTRODUCTION - continued

1.3 Summary of the Source Report - continued

Item	Description	Capital Cost	Annual Savings	Payback Period	Remarks
25	Caulk and weatherstrip windows.	$ 1,000	$ 105	9.6 years	
26	Repair ductwork.	N/R	N/R	N/R	Measure k
27	Change ice surface lighting with a) 400 watt metal halide.	$16,800	$ 620	27.1 years	
	b) 250 watt high pressure sodium	$14,340	$ 1,142	18.0 years	
	or c) super high output fluorescent.	$ 7,000	$ 653	10.7 years	Measure 8
28	Upgrade arena ventilation unit				
	1. Move room thermostats.	$ 500	N/R	N/R	Measure 7
	2. Replace broken freeze stat.	$ 500	-	N/R	Measure 7
	3. Manual control of outside air.	$ 1,000	$ 660	1.5 years	Measure 7
	4. Low leakage dampers.	$ 3,000	$ 395	7.6 years	Measure 7
	5. Ceiling destratification fans.	$10,000	$ 434	23.0 years	Measure 9
	6. Operate on night cycle - install air dryer	N/C	N/R	N/R	Measure 7
	7. Install CO_2 sensors.	$ 5,000	N/R	N/R	
	SUB-TOTAL Item 28	$20,000	$ 1,490	14.8 years	
29	Reinsulate 2nd floor supply air ducting.	$ 1,500	$ 123	12.2 years	
30	Insulate DHW piping.	$ 1,300	$ 92	14.1 years	
31	Insulate windows.	$ 1,500	$ 105	14.3 years	
32	Upgrade lobby ventilation unit.				
	1. Replace day/night switch and resequence control.	$ 4,000	N/R	N/R	Measure 10
	2. Replace underseat exhaust fan.	$ 6,000	N/R	N/R	Measure 10 Rebalance only.
	3. Low leakage dampers	$ 1,000	N/R	N/R	Measure 10
	4. Provide run timer.	$ 500	N/R	N/R	Measure 10
	5. Steam radiation in space	N/R	N/R	N/R	
	SUB-TOTAL	$11,500	$ 784	14.7	Measure 10

1. INTRODUCTION - continued

1.3 Summary of the Source Report- continued

Item	Description	Capital Cost	Annual Savings	Payback Period	Remarks
33	Add door closures to the change rooms.	$ 100	N/R	N/R	Per door
34	Add a refrigerated control air dryer.	$ 2,000	N/R	N/R	Measure 7
35	Apply sealer to concrete	$ 7,600	$ 310	24.5 years	
36	Infrared heaters in arena.	$ 800	$ 2,900	0.3 years	

1.4 Measures Chosen For Retrofit

The Phase II measures selected for implementation differ slightly from the source report as follows:

Measure 3 vs. Item 19. Savings differ.
Measure 4 vs. Item 15. Source report indicates 3 thermostats, vs. 4 thermostats. Only 3 thermostats were added.
Measure 9 vs. Item 28.5. Capital costs and savings differ.

Agreements with the City of North Battleford were prepared. Several measures were to be implemented by the City without consultants. The following measures were to be implemented through Saskmont Engineering.

Measure	Description	Cost	Annual Saving	Payback Period
1	Install ice temperature sensor to control brine pump circulation	$ 1,000	$1,000	1 year
2	Insulate steam and condensate piping in the east side underseat arena.	3,500	860	4 years
3	Replace existing incandescent lighting over seating with fluorescent.	3,500	570	6.2 years
4	Reclaim heat from evaporative condenser to heat domestic hot water.	2,000	220	9 years
5	Install thermostat controlled valves on lounge radiators	1,200	250	5 years

1. INTRODUCTION - continued

1.4 Measures Chosen For Retrofit - continued

Measure	Description	Cost	Annual Saving	Payback Period
6	Modify lounge ventilation system.	4,900	520	9.4 years
7	Modify arena ventilaton system.	7,000	1,050	6.7 years
8	Replace arena mercury vapour lighting with higher efficiency light source.	7,000	700	10 years
9	Install antistratification fans in arena.	$ 6,000	$1,000	6 years
10	Modify lobby ventilation system.	5,500	780	7.9 years
11	Interlock washroom exhaust fan with supply unit.	300	-	-
	Totals	$41,900	$6,935	6 years

During the fall of 1983 Saskmont prepared drawings and specifications for the above measures. (See technical drawings and specifications in Appendix IV).

Under the agreement, the City of North Battleford were to implement the following measures directly.

Measure	Description
a)	Operate DHW recirculation pump only during periods of hot water demand.
b)	Reduce DHW temperature from 140°F to 120°F.
c)	Reduce setpoints of thermostats to 68°F in the upstairs lounge and the lower lobby for day time heating.
d)	Isolate the auxillary gas fired DHW heater when the boiler is not operating.
e)	Ensure the window in the ambulance room remains closed.

1. INTRODUCTION - continued

1.4 Measures Chosen For Retrofit - continued

Measure	Description
f)	Caulk the corner of the ceiling and south wall inside the upstairs lobby.
g)	Descale the evaporative condenser.
h)	Replace access cover on upper level fan unit.
i)	Repair back draft dampers on exhaust fans and install weatherstripping or replace backdraft dampers with low leakage dampers.
j)	Replace fluorescent lamps in corridor with watt-mizer type as existing lamps burn out.
k)	Repair supply air ducting by pulling it into original position and taping all joints to be airtight.

1.5 Measures Implemented

Measures 1 through 11 were implemented, and Measure a) through k) were partially implemented during the winter of 1984. This report contains the technical details of the work and estimate the resulting energy savings.

A complete summary of the work is contained in Section 5 of this report.

2. TECHNICAL ANALYSIS

2.0 Methodology

The energy calculations done in this section of report are done on the basis of the calculation methodology contained in Appendix II. Reference is made to the appendix by stating "calculation C-2" or merely "C-2".

Assumptions made are generally based upon the source report and a review of the plans, specification and building.

All calculations have been done in detail in order to explain the assumptions used, however this does not improve the accuracy. In most cases the accuracy is at best ±20%.

Utility costs used in this report are as follows.

Gas	13.94¢/m^3
Electricity	$9.72/KVA demand
	2.72¢/kWhr. consumption

These costs differ from other buildings in the study as there is a demand meter in this building.

2. TECHNICAL ANALYSIS - continued

2.1 Measure 1 - Brine Pump Controls

Situation - The ice plant brine pump circulates brine through the floor slab constantly. The temperature of the floor slab is controlled by cycling the ammonia compressors from a temperature sensor in the brine return line.

The brine pump utilizes a 25HP motor and due to the above operation it runs unnecessarily some of the time.

Solution - The source report recommended the installation of an ice temperature sensor to shut off the brine pump when ice temperatures were satisfactory.

This work was done directly by North Battleford.

Energy Calculations

The ice plant is in operation for 4,320 hours per year, thus energy consumed by the brine pump is:

C-1: 25 x 1 x .80 x 4320 x 1.0 = 86,400 kWhrs.

By installing the ice temperature sensor it is assumed that the brine pump operation is reduced by 50%. Savings are then:

50% of 86,400 = 43,200 kWhrs. at 2.72¢/kWhrs = $1,175.00/year

2. TECHNICAL ANALYSIS - continued

2.2 Measure 2 - Insulate Steam Piping

Situation - Steam piping from the boiler runs through a concealed space above the change rooms and canteen to the various unit heaters and air handlers. None of this steam piping is insulated and as a result these concealed areas are overheated.

Solution - The source report recommended insulation of the steam lines with 1" thick fiberglass insulation.

Drawing and specifications of the steam line insulation were prepared and tendered in late December. (See Appendix IV for drawings and specifications).

Energy Calculations - From the existing building drawings the following pipe lengths and sizes were determined:

Pipe Size	Length (ft.)	Uninsulated* Heat Loss (BTUH/ft.)	Insulated* Heat Loss (BTUH/ft.)	Heat Loss Savings (BTUH)
1"	90	111.0	16.2	8532
1¼"	260	137.8	21.0	30368
1½"	170	155.7	21.4	22831
2"	150	191.1	24.6	24975
3"	70	273.7	33.6	16807
8"	80	631.3	70.1	44896
			TOTAL	148409

*Thermal conductance of insulation at 0.240 BTU. in/hr. ft.^{2} °F. Average pipeline temperature of 200°F. Ceiling temperature of 80°F.

Thus assuming that 50% of the above heat loss is wasted, (the remainder of heat loss provides heating to the building) and assuming the boiler in operation for 8 months or 5840 hours per year, the savings are:

$$.50 \times \frac{148409 \times 5840}{35313 \times .70} = 17531 m^3 \text{ of natural gas}$$

or $2444 per year.

2. TECHNICAL ANALYSIS - continued

2.3 Measure 3 - Improve Lighting Over Bleachers

Situation - Lighting over the bleachers is presently done with 20 - 300 watt incandescent fixtures. As incandescent fixtures are the least efficient type of lighting, consideration was given to going to a more efficient light source.

Solution - The source report recommended replacing the 20 - 300 watt light fixtures with 30 - 47 watt fluorescent light fixtures.

The design soluton chosen was to leave the 6 incandescent lights over the exits in place. This was done to allow easy replacement of these fixtures on burn-out (pole replacement ment versus ladders).

Six additional light along the north wall were found to be unnecessary and thus should have the bulbs permanently removed.

The remaining 8 incandescent fixtures were replaced with 8 - 96 watt fluorescent fixtures. (See technical drawings and specifications in Appendix IV).

Energy Calculations - The bleacher lights are assumed to operate for 20 weeks per year for 21 hours per week (3 hours/day) or 420 hours per year. Then current electrical costs are:

Electrical Demand: 20 fixt. x 300w/1000 = 6KVA/month

Consumption: 6KVA x 420 hours = 2520 kWhrs/year

New electrical consumption is:

Electrical Demand: (6 fixt. x 300w + 8 fixt. x 96w)/1000 = 2.6 KVA per month

Consumption: 2.6 x 420 hours = 1092 kWhrs/year

Savings are thus 1428 kWhrs/year and 3.4 KVA per month saving. Demand likely occurs over a 10 month period only. Therefore annual savings are:

1428 kWhrs x 2.72¢	$ 39
3.4 KVA x 10 x $9.72	330
	$369/year

2. TECHNICAL ANALYSIS - continued

2.4 Measure 4 - Reclaim Heat From Ice Plant

Situation - The ice in the arena is made with an ammonia brine ice plant consisting of two - 75HP Mycom compressors.

All heat is rejected outside the building via a Cimco evaporative condenser.

At the same time the boiler is used to produce domestic hot water for showering and other activities.

Solution - The source report recommended the installation of a heat recovery device to heat domestic hot water.

A Therma-stor tank was selected for this duty. Technical drawings and specifications are contained in Appendix IV.

Energy Calculations

The ice plant is assumed to operate as follows: (total heat rejection 800,000 BTUH per compressor, 15% as superheat)

	HOURS OF OPERATION		Average Peak Available Superheat Day (MBH)	Average Peak Available Superheat Night (MBH)	Total Superheat Available (x 10^6 BTU)
	Comp #1	Comp#2			
July	0	0	0	0	0
August	744	744	240.0	240.0	178.6
September	746	504	240.0	168.0	146.9
October	744	364	237.4	120.0	133.0
November	720	164	174.7	120.0	106.0
December	648	60	139.4	89.0	85.0
January	583	30	129.7	68.1	73.6
February	605	40	134.3	96.1	77.4
March	744	164	172.9	120.0	109.0
April	360	288	240.0	192.0	77.8
May	0	0	0	0	0
June	0	0	0	0	0
Total	5894	2358			987.3

Domestic hot water use is based upon a fixture count and tables 1, 6, 7, and 13 of ASHRAE - 1980 - Chapter 37. Domestic hot water use is estimated to be as follows (less ice flooding):

	GPH	MBH
Standby loss =	0	20.3
Average 24 hour load =	43.9	56.9
Average 12 hour load =	87.8	93.4
Peak 1 hour load =	585.0	507.8

2. TECHNICAL ANALYSIS - continued

2.4 Measure 4 - Reclaim Heat From Ice Plant - continued

Energy Calculations - continued

Ice flooding is assumed to consist of 1200 floods per season with 90 US gal. of water per flood at 140°F. Then total domestic hot water load is estimated to be as follows:

	Average Daytime Peak Load (MBH)	Average Nighttime Peak Load (MBH)	Total Energy Use (x 10^6 BTU)	Gas (m^3)
July	20.3	20.3	15.1	610
August	125.3	20.3	54.2	2191
September	125.3	20.3	52.4	2120
October	125.3	20.3	54.2	2191
November	125.3	20.3	52.4	2120
December	125.3	20.3	54.2	2191
January	125.3	20.3	54.2	2191
February	125.3	20.3	48.9	1979
March	125.3	20.3	54.2	2191
April (½ month)	125.3/20.3	20.3	33.5	1355
May	20.3	20.3	15.1	610
June	20.3	20.3	14.6	591
Total			503.0	20340

Thus total recoverable heat using a 100,000 BTU Therma-stor tank is as follows:

	Recoverable Heat Day (MBH)	Night (MBH)	Total Energy Recovered (x 10^6 BTU)	Natural Gas Saved (m^3)
July	0	0	0	0
August	100.0	20.3	44.8	1810
September	100.0	20.3	43.3	1752
October	100.0	20.3	44.8	1810
November	100.0	20.3	43.3	1752
December	100.0	20.3	44.8	1810
January	100.0	20.3	44.8	1810
February	100.0	20.3	40.4	1635
March	100.0	20.3	44.8	1810
April (½ mo.)	100/0	20.3/0	21.7	876
May	0	0	0	0
June	0	0	0	0
Total			372.7	15065m^3

Thus annual energy saving will be 15065m^3 x 13.94¢ = $2100/year.

2. TECHNICAL ANALYSIS - continued

2.5 Measure 5 - New Thermostats

Situation - The upper lounge cloakroom, the east entrance and the east ticket booth are heated with steam through wall fin radiation. These heaters are uncontrolled, wasting heat at times by overheating the spaces.

Solution - The source report recommended installation of control valves and thermostats on these heaters. Drawings were prepared and tendered. (See Appendix III).

Energy Calculations

For The Lounge Cloak Room

	Area (SF)	U-Value	U x A
Walls	446	0.24	107.0
Windows	250	0.67	167.5
Roof	640	0.076	48.6
Infiltration:			
windows	110 ft. x 15/60/2 = 13.8 CFM	1.1	15.2
walls	446 x 3/60/2 = 11.2 CFM	1.1	12.3
		TOTAL	350.6

Then C-12: $\frac{350.6 \times 10970 \times 24 \times .7 \times 0.4}{35313 \times .7} = 1046 m^3$ of natural gas

Annual savings are $146/year.

For The East Entrance

	Area (SF)	U-Value	U x A
Wall	147	0.24	35.3
Doors	63	0.67	42.2
Roof	140 SF	0.076	10.6
Infiltration			
Doors	60 ft. x 140/60/2 = 70 CFM	1.1	77.0
Wall	147 x 3/60/2 = 3.7 CFM	1.1	4.0
		TOTAL	169.1

C-12: $\frac{169.1 \times 10970 \times 24 \times .7 \times 0.4}{35313 \times .7} = 505 m^3$

Annual savings are $70/year.

2. TECHNICAL ANALYSIS - continued

2.5 Measure 5 - New Thermostats - continued

Energy Calculations

For The East Ticket Booth

	Area	U-Value	U x A
Wall	98 SF	0.24	23.5
Roof	65 SF	0.076	4.9
Infiltration	98 x 3/60/2 = 2.5 CFM	1.1	2.7
		TOTAL	31.1

C-12: $\frac{31.7 \times 10970 \times 24 \times .7 \times .4}{35313 \times .7} = 193 m^3$ of natural gas

Annual savings are $13/year.

Thus in summary savings are as follows:

	Gas	Savings
Lounge Cloak Room	1046 m^3	$146
East Entrance	505 m^3	70
East Ticket Booth	93 m^3	13
Total	1644 m^3	$229

2. TECHNICAL ANALYSIS - continued

2.6 Measure 6 - Modify Lounge Ventilation System

Situation - The lounge ventilation system consists of constant variable temperature fan systems located in the mechanical room. Return air passes through a face and bypass steam coil, through a fan, through a Dx cooling and then passes to the lounge. When the system is on day operation the outside air dampers are manually controlled, if the outside air dampers are opened sufficiently an ancillary exhaust fan is turned on.

The lounge system does not work well. It overheats in the summer despite the airconditioning system, it is stuffy and the ancillary fan is noisy. In addition the fan is not usually operated in night setback mode.

Solution - The source report recommended the installation of low leakage outside air dampers to ensure minimum energy use during night setback and a time clock to ensure that the night setback cycle is utilized.

The source report further recommended abandoning the ancillary fan and the installation of a return fan and mixing box to improve the comfort and quality of the system.

Drawings and specifications were prepared and are included in Appendix III.

Energy Calculations

The existing fan system operates 8,760 hours per year.

Assume with the time clock that the fan system operates on day cycle for 20 hours per week. Assume that the temperature was normally set back prior to the new installation, therefore there are no direct savings due to reduced temperatures. There are however savings due to reduced damper leakage and reduced fan operation at night.

Reduced fan operation:

C-1: 3HP x 1 x 0.8 x 7717 x 50% = 9,260 kWhrs per year

Reduced damper leakage where existing damper leakage is assumed to be 30% of 5600 = 1680 CFM.

$$\text{C-2: } \frac{1680 \times 1.1 \times (60 - 35) \times 1.0 \times 7717 \times 1.0}{35313 \times .7} = 14{,}423 m^3$$

less air leakage by new damper at 1% of 5,600 CFM = 56 CFM

2. TECHNICAL ANALYSIS - continued

2.6 Measure 6 - Modify Lounge Ventilation System - continued

Energy Calculations - continued

C-2: $\frac{56 \times 1.1 \times (60 - 35) \times 1.0 \times 7717 \times .5}{35313 \times .7} = 240m^3$

Total saving 14423 - 240 = 14183m^3

There will be some marginal energy savings associated with reduced cooling. Assuming that these are small, total energy savings are:

Gas	14,183m^3	at 13.94¢/m^3	$1,977
Elec.	9,260 kWhrs	at 2.72¢/kWhrs	252
Total			$2,229

2. TECHNICAL ANALYSIS - continued

2.7 Measure 7 - Modify Arena Ventilation System

Situation - The arena is heated with a constant volume variable temperature forced air system. The air handler is located on a stand above the seating on the north end of the arena.

Return air is taken from the arena through a face and bypass steam coil through the fan and ducted to blow down across the bleachers on either side of the arena.

The fan system is equipped with a day/night control but the control system does not work as there is no air dryer in the pneumatic control system.

In addition the control setpoints on day operation generally result in the system operating on 100% outside air.

Solution - The source report recommended the installation of a refrigerated air dryer onto the pneumatic control system to allow the control system to function properly. In addition the mixed air controls were to be replaced with manual controls (a gradual switch), with instructions to leave the dampers closed most of the time. Finally the day/night switch was to be made operable and equipped with a time clock and the outside air damper was to be replaced with a low leakage outside air damper.

Drawings and specifications were prepared and are enclosed in Appendix IV.

Energy Calculations - The existing fan system ran about 2 to 4 hours (September 1 to April 15) and is shut off in summer (227 days x 3 hours = 681 hours per year).

With the time clock in place the fan will continue to run 2 to 4 hours a day. Thus there is little energy saved due to reduced fan operation:

With manual control of outside air dampers, these dampers will remain shut most of the time. Assuming the old dampers due to the control system remained 80% open most of the time. Annual savings are calculated using equation C-2:

Outside air = 80% of 18,500 CFM = 14,800 CFM changed to 1% of 18,500 = 185 CFM

Arena temperature 45°F

2. TECHNICAL ANALYSIS - continued

2.7 Measure 7 - Modify Arena Ventilation System - continued

Energy Calculations - continued

$$\frac{(14{,}800 - 185) \times 1.1 \times (45 - 35) \times 1.0 \times 90\% \times 681}{35313 \times .7} = 3{,}986 m^3 \text{ gas}$$

Total Savings are $3{,}986 m^3$ of gas at 13.94¢ or $555 per year.

2. TECHNICAL ANALYSIS

2.8 Measure 8 - Improve Arena Lighting

Situation - The lighting over the ice in the arena consisted of 40 - 400 watt mercury vapour light fixtures providing approximately 30 foot candles of light to the ice surface.

The lighting levels were slightly below that recommended for ice arenas (50 foot candles). In addition mercury vapour is not the most efficient light source possible.

Solution - The source report recommended replacement of the mercury vapour light with a higher efficient light source.

This work was designed and tendered directly by the City of North Battleford. The City chose to use 32 - 400 watt metal halide lamps, providing a slight increase in the light level in the arena.

Energy Calculations - Assuming 1500 hours per year of operation energy savings are as follows:

Demand $\frac{40 \times 400 \text{ watt} - 32 \times 400 \text{ watts}}{1000} = 3.2$ KVA for 9 months

Consumption using C-1: 32 KVA x 1500 = 4800 kWhrs.

Therefore total savings are:

Electricity consumption	4800 Kwhrs at 2.72¢	= $131
Demand	3.2 KVA x 9 at $9.72	= $279
Total		$410/year

2. TECHNICAL ANALYSIS - continued

2.9 Measure 9 - Destratification Fans.

Situation - The arena is a high ceiling room heated by a forced air system. The ceiling temperatures will normally be higher than average temperature.

When the ceiling temperatures are higher than average the heat loss from the building is higher than need be and the radiant loads on the ice surface are higher than needed.

Solution - The source report recommended the installation of ceiling destratification fans to reduce ceiling temperatures.

These fans were installed over the bleacher area blowing down for the following reasons:

1 - installation at the ceiling peak would have been more expensive since the ice was in the arena and hence it was not possible to bring in large equipment to aid in the installation.

2 - Installation over the bleachers minimizes the effect of downdrafts on the ice surface.

3 - Installation over the bleachers is opposite to the installation in Yorkton and thus comparative results with Yorkton may be obtained on this controversial issue.

4 - The arena roof is a low emittance roof thus downdraft on the ice should be avoided.

Energy Calculations:

Energy saved by this measure is calculated using calculation C-6. Since North Battleford is used as an example in C-6 the calculations are not repeated.

For a low emittance ceiling savings are: (with the fans over the bleachers)

Gas	30196m^3	at 13.94¢	$4,209
Elec.	33093 Kwhrs	at 2.72¢	900
Total			$5,109/year

2.0 TECHNICAL ANALYSIS - continued

2.10 Measure 10 - Modify Lobby Ventilation

Situation - The lobby is heated with a constant volume variable temperature fan system. Return air is taken from the lobby passed through a face and by-pass steam heating coil, through the fan and then supplied to the lobby.

The system is controlled by a day/night switch. On day operation the fan is to run continuously and the outside air dampers are manually controlled. An ancillary (underseat) exhaust fan is to run during the day.

In practice the underseat exhaust fan was seldom run due to noise and draft complaints.

On night cycle the underseat exhaust fan was to remain off and the outside air dampers were to close and the fan was to cycle to maintain the night space temperature. In practice night set back was seldom used.

Solution - The source report recommended installation of a 3 position switch controlled by run timers. (High occupancy day, low occupancy day/night).

During high occupancy day the washroom and underseat exhaust fans were to be on, the mixed air temperature was to be controlled to 55°F, the supply fan was to run continuously and heating was to be controlled by the day thermostat. A 4 hour run timer was to switch the unit back to low occupancy day unless reset.

During low occupancy day the washroom exhaust fan was to be on, the underseat exhaust fan was to be off, the outside air dampers were to be closed and the supply fan was to run intermittently to maintain space temperatures as set by the day thermostat.

Changing from low occupancy day to night setting would be manual. At night the washroom exhaust fan would be off. The supply fan would cycle to maintain space temperatures as set by the night thermostat.

To minimize energy use at night the source report recommended the installation of low leakage outside air dampers.

To eliminate much of the noise and draft complaints the source report recommended that the underseat exhaust fan be replaced with a new smaller exhaust fan and the exhaust air volumes be reduced.

All of the above, except for replacement of the underseat exhaust fan was designed and tendered. (See technical drawings and specifications in Appendix IV). The underseat exhaust fan air volumes were reduced in accordance with the report but the exhaust fan was not changed, merely rebalanced.

2.0 TECHNICAL ANALYSIS - continued

2.10 Measure 10 - Modify Lobby Ventilation - continued

Energy Calculations

In the existing installation:

- the washroom exhaust fan runs continuously
- the supply fan runs continuously
- the underseat exhaust fan seldom runs
- air leaks through the outside air dampers at an estimated 30%
- the system is seldom run on night cycle
- the system operates between September 1 and May 30th.

For the new system it is assumed that:

- the system is on night cycle 12 hours/day
- the system is on low occupancy cycle for 8 hours/day
- the system is on high occupancy for 4 hours/day
- the system operates between September 1 and May 31st.

During summer months the system is assumed to be off in both cases.

Energy Saved by Reduced Fan Operation

	Existing	New			Total
	(Hours/Day)	Night (12)	Low Day (8)	High Day (4)	Hrs./Day
Washroom Exhaust Fan (0.1HP)	24	0	8	4	12
Underseat Exhaust Fan (2 HP)	1	0	0	4	4
Supply Fan (3 HP)	24	6	4	4	14

Therefore hours saved per year are:

Washroom Exhaust Fan (24 - 12) x 273 days = 3,276 hours
Underseat Exhaust Fan (1 - 4) x 273 days = -819 hours (increase)
Supply Fan (24 - 14) x 273 days = 2,730 hours

And savings using calculation C-1 are:

Washroom Exhaust Fan (1/10 HP) (1) (.8) (3276) (1.0) = 262 kWhrs.
Underseat Exhaust Fan (2 HP) (1) (.5) (-819) (1.0) = -819 kWhrs. (increase)
Supply Fan (3 HP) (1) (.8) (2730) (1.0) = 6,552 kWhrs.
Total = 5,995 kWhrs.

2.0 TECHNICAL ANALYSIS - continued

2.10 Measure 10 - Modify Lobby Ventilation - continued

Energy Calculations - continued

Energy Saved by Reduced Outside Air

Washroom Exhaust Fan-850 CFM air is taken via infiltration through the supply fan louvres and is heated to 70°F all year. In the new system this fan is off at night. During low day operation air is taken by infiltration. During high day operation air is taken through the supply fan.

The underseat exhaust fan exhausted 5600 CFM for 1 hour per day and was changed to exhaust 1008 CFM for 4 hours per day, all air taken through the supply fan.

The main supply (5600 CFM) uses less outside air as the outside air dampers have been changed to low leakage dampers.

Outside air leakage is estimated as follows:

	Night (12 Hrs)	Low Day (8 Hrs)	High Day (3 Hrs)	High Day (1 Hr.)
Hours of Operation	3276	2184	819	273
Existing (30%)	1680 CFM	1680 CFM	1680 CFM	5600 CFM
New (1%) leakage	56 CFM	56 CFM	1858 CFM	1858 CFM
New Including Washroom exhaust and underseat exhaust fan	56 CFM	850 CFM	1858 CFM	1858 CFM
Discharge temp. -old	70°F	70°F	70°F	70°F
-new	55°F	70°F	70°F	70°F

Thus savings using calculation C-2:

Night: $\frac{[1680 \times (70 - 35) - 56\ (55 - 35)] \times 1.1 \times 1.0 \times .9 \times 3276}{35313 \times .7} = 7568m^3$

Low Day: $\frac{[1680 - 850] \times (70 - 35) \times 1.1 \times 1.0 \times 1.0 \times 2184}{35313 \times .7} = 2823m^3$

High Day (3 hrs): $\frac{[1680 - 1858] \times (70 - 35) \times 1.1 \times 1.0 \times 1.0 \times 819}{35313 \times .7} = -227m^3$ (increase)

High Day (1 hr): $\frac{[5600 - 1858] \times (70 - 35) \times 1.1 \times 1.0 \times 1.0 \times 273}{35313 \times .7} = 1591m^3$

Total savings = $11755m^3$

2.0 TECHNICAL ANALYSIS - continued

2.10 Measure 10 - Modify Lobby Ventilation - continued

Energy Calculations

In the existing installation:

- the washroom exhaust fan runs continuously
- the supply fan runs continuously
- the underseat exhaust fan seldom runs
- air leaks through the outside air dampers at an estimated 30%
- the system is seldom run on night cycle
- the system operates between September 1 and May 30th.

For the new system it is assumed that:

- the system is on night cycle 12 hours/day
- the system is on low occupancy cycle for 8 hours/day
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Supply Fan (3 HP) (1) (.8) (2730) (1.0) = 6,552 kWhrs.
Total = 5,995 kWhrs.

2.0 TECHNICAL ANALYSIS - continued

2.10 Measure 10 - Modify Lobby Ventilation - continued

Energy Calculations - continued

Energy Saved by Reduced Outside Air

Washroom Exhaust Fan-850 CFM air is taken via infiltration through the supply fan louvres and is heated to 70°F all year. In the new system this fan is off at night. During low day operation air is taken by infiltration. During high day operation air is taken through the supply fan.

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New (1%) leakage	56 CFM	56 CFM	1858 CFM	1858 CFM
New Including Washroom exhaust and underseat exhaust fan	56 CFM	850 CFM	1858 CFM	1858 CFM
Discharge temp. -old	70°F	70°F	70°F	70°F
-new	55°F	70°F	70°F	70°F

Thus savings using calculation C-2:

Night: $\frac{[1680 \times (70 - 35) - 56\ (55 - 35)] \times 1.1 \times 1.0 \times .9 \times 3276}{35313 \times .7} = 7568m^3$

Low Day: $\frac{[1680 - 850] \times (70 - 35) \times 1.1 \times 1.0 \times 1.0 \times 2184}{35313 \times .7} = 2823m^3$

High Day: (3 hrs) $\frac{[1680 - 1858] \times (70 - 35) \times 1.1 \times 1.0 \times 1.0 \times 819}{35313 \times .7} = -227m^3$ (increase)

High Day: (1 hr) $\frac{[5600 - 1858] \times (70 - 35) \times 1.1 \times 1.0 \times 1.0 \times 273}{35313 \times .7} = 1591m^3$

Total savings = $11755m^3$

2.0 TECHNICAL ANALYSIS - continued

2.10 Measure 10 - Modify Lobby Ventilation - continued

Energy Calculations - continued

Energy Saved Due To Night Setback

BTUH (Exterior)		Area	U	U x A
Windows non operable 6 x 12.2SF	=	73.2 SF	0.59	43.2
operable 6 x 12.2SF	=	73.2 SF	0.59	43.2
Exterior Wall	=	1659.6 SF	0.24	398.3
Infiltration				
non operable windows 6 x 14' x 15/60/2	=	10.5 CFM	1.1	11.6
operable windows 6 x 14' x 40/60/2	=	28.0 CFM	1.1	30.8
wall 1659.6 SF x 3/60/2	=	41.4 CFM	1.1	45.5
Total				572.6

BTUH (Interior)	Area	U	U x A
Partition walls	2268 SF	0.5	1134.0
roof	946 SF	0.5	473.0
Total			1607.0

Therefore total energy saved by night setback of 12 hours per day (84 hours/week) 55°F is: Assume a 35 week heating season.

C-6: $\frac{(572.6 + 1607.0) \times 35 \times 84 \times 15 \times 0.8}{35313 \times .7} = 3111 m^3$

In summary the total energy savings due to measure 10 are:

Electricity	5995 kWhrs	at 2.72¢	$ 163
Gas	1486 m^3	at 13.94¢	$2072
Total			$2235/year

2.0 TECHNICAL ANALYSIS - continued

2.11 Measure 11 - Interlock Washroom Exhaust

Situation - The washroom exhausts ran 8,760 hours per year.

Solution - Implementation of this measure was done through measure 6 and 10. Costs and energy calculations are taken into account in those sections.

3.0 OWNERS RETROFIT

North Battleford's direct work on the project is itemized in Section 1.1. The following is a summary of the action they have undertaken. Energy savings indicated have been adjusted to this report's marginal fuel costs and have been adjusted to account for the implementation of the engineered measures.

Measure a) - Cycle DHW Circulation Pumps -The owners were to shut this pump off when the building was unoccupied.

- Savings - 290m^3 gas
  - 496 kWhrs. electricty
  - $40/year

- This operating procedure has been implemented by North Battleford.

Measure b) - Reduce DHW Temperatures - The owners were to lower their domestic hot water temperature to 120°F.

- Savings - 340m^3 gas
  - $47/year

- This has been done by North Battleford.

Measure c) - Reduce Thermostat Setpoint - The owners were to lower the thermostat setpoints in the lounge and lobby to 68°F during the day.

- Savings - C6: $\frac{(2 \times 2179.6) \times 35 \times 84 \times 2 \times 0.8}{35313 \times .7} = 830m^3$ gas
  - $116/year

- This has been done by North Battleford.

Measure d) Isolate Gas Fired DHW Heater in Winter - The owners were to shut off the gate valves isolating this heater. In addition the gas line was to be isolated.

- Savings - 42m^3 gas
  - $6/year

- This has been done by North Battleford.

Measure e) Ambulance Room Window - The ambulance room window was to be kept closed.

- Savings - 16m^3 gas
  - $2/year

- This window is being kept closed.

3. OWNERS RETROFIT - continued

Measure f) - Caulk Well At South Soffit - The owner was to caulk the joint near the roof on the south wall.

- Savings - 1478m^3 gas
  - $207/year

- This work is scheduled for the summer of 1984.

Measure g) - Descale Evaporative Condenser - The owner was to clean the evaporative condenser and to ensure the application of proper water treatment to the system.

- Savings - no direct savings.

- The condenser has been descaled.

Measure h) - Replace Access Cover On UpperLevel Fan Unit - The owner was to replace the access cover as air was being wasted into the mechanical room.

- Savings - not calculated (small)

- This work has been done by North Battleford.

Measure i) - Replace Backdraft Damper - The owner was to replace or repair the backdraft damper on the underseat and upper lounge exhaust fans. The upper lounge exhaust fan is being removed as part of Measure 6, leaving only the underseat exhaust from backdraft damper.

- Savings - not calculated (small)

- This work is scheduled for the summer of 1984.

Measure j) - Replace Fluorescent Lamps In Corridor With Watt-Mizer Lamps. The owner was to begin using high output fluorescent lamps on a burnout basis.

- Savings - 6 Kwhrs/year/lamp
  - 16¢/year/lamp

- North Battleford has implemented this work.

Measure k) - Repair Supply Air Ducting - The owner was to repair the supply air ducting, especially the lounge unit ducting that runs through the arena to reduce duct leakage.

- Savings - not calculated.

- This work is scheduled for the summer of 1984.

4. MONITORING PROGRAM

The purpose of the monitoring program is to confirm that the savings estimated in this energy analysis report and source report are actually achieved, thus confirming the calculation methodology, the assumptions made and further demonstrating the successful economics of retrofitting recreation facilities.

To date there has been no monitoring of the building except for SPC's reading of the gas and electrical meter. The history of the building is further muddied by the fact that the electric meter for the building is not separate but serves the entire site.

The building is currently estimated to use about 61 EKWH/SF/year. Table 4.1 summarizes the current energy pattern of the building and the expected energy reductions that will occur.

Our recommended monitoring program is as follows:

TABLE 4.1 SUMMARY OF MEASURES TAKEN TO REDUCE ENERGY CONSUMPTION

Measure	Description	Gas (m^3)	Percent Change	Electrical MWhrs	Percent Change	KVA/yr.	Percent Change
	Current average use.	205123		992.6		3317	
	Range of current use.	±31217	±15.3%	±59.6	±60%	±283	±8.5%
1	Brine pump			-86.4	-11.1%		
2	Insulate piping	-17531	-11.7%				
3	Light over bleachers	negl.		- 1.1	- 0.1%	- 26	-0.8%
4	Heat reclaim	-15065	- 7.3%	negl.		negl.	
5	New thermostats	- 1644	- 0.8%				
6	Lounge vent system	-14183	- 6.9%	- 9.3	- 9.9%		
7	Arena vent system	- 3986	- 1.9%	0	--		
8	Arena lights	negl.		- 4.8	- 0.5%	- 29	-0.9%
9	Destratification fans	-30196	-14.7%	-33.1	- 3.3%		
10	Lobby	-14866	- 7.2%	- 6.0	- 0.6%		
a/k	Owners retrofit	- 2889	- 1.4%	- 0.7	- 0.1%		
	Savings Total	-100350	-48.9%	-141.4	-14.2%	- 55	-1.7%
	Expected Energy Use	104773		851.2		3262	

4. MONITORING PROGRAM - continued

Overall Program Results

In order to demonstrate the overall effectiveness of the measures weekly readings are required to be taken on:

- existing SPC electric meter (KVA & kWhrs.)
- existing SPC gas meter
- new electric meter (KVA & kWhrs.)

The new electric meter will be used to isolate the arena power meter from the pool and site power usage.

The readings in general will be used to demonstrate whether the 62% reduction gas usage and 16% reduction in electrical usage was obtained.

Note: The savings in demand are too small to be effectively demonstrated.

A plot of these readings and of the previous years SPC readings made against degree days (or some area measure of weather) can be made to smooth the data and compare results.

Measure 1 - Brine Pump Controls

In order to confirm the energy saved by cycling the brine pump, a run timer should be installed to record the hours of operation of the brine pump.

The run time should be recorded on a weekly basis.

Measure 2 - Insulate Steam Piping

There is no way of directly monitoring this item. Effectiveness must be measured in terms of the overall program results.

Measure 3 - Improve Lighting Over Seats

A run timer could be installed to measure the use of these lights thus confirming the assumptions made. As the savings due to this measure are only $369/year, it may not justify the installation of a run timer. In its place a weekly report on bleacher light operation could be used.

Measure 4 - Reclaim Heat from Ice Plant

The calculations made for the ice plant were based upon assumptions of the ice plant operating time and quantitites of the domestic hot water used. To verify these assumptions the following monitoring is required:

4. MONITORING PROGRAM - continued

Measure 4 - Reclaim Heat from Ice Plant - continued

- Weekly recording of the existing run timers of the ice plant compressors.
- Installation of a domestic hot water meter to record domestic hot water use, recorded weekly.

In addition a BTU meter could be installed on the heat recovery line and recorded weekly.

The BTU meter would provide the most precise result of heat recovery and the run timers and domestic water meter would be used to verify original assumptions and calculation procedures.

Measure 5 - New Thermostats

There is no way of directly monitoring this item and effectivenss cannot be determined by overall program results as the percentage change is too small.

Measure 6 - Lounge Ventilation

To demonstrate the savings for this measure, run timers should be installed and read weekly on:

- the supply fan
- the day/night switch

These will confirm the assumptions made in the energy calculations.

In addition a weekly report should record:

- day thermostat setpoints
- night thermostat setpoints
- remarks

Measure 7 - Arena Ventilation

To demonstrate the savings for the measure the following run timers should be installed and recorded weekly:

- the supply fans

In addition the weekly report should contain:

- day thermostat setpoint
- night thermostat setpoint
- time clock setting
- set points of mixed air dampers
- remarks

4. MONITORING PROGRAM - continued

Measure 8 - Arena Lighting

To confirm assumptions made for this measure a run timer should be installed to the record weekly use of the arena lights.

Measure 9 - Destratification Fans

To confirm assumptions made for this measure the following data should be collected:

	Fans Off	Fans On
Temperature of air over ice	_____	_____
Temperature of air at ceiling	_____	_____
Ice temperature	_____	_____
Air velocity over ice	_____	_____
Outside air temperature	_____	_____

These measurements should be made at various times throughout the year.

To directly measure the affect of the destratification fans a weekly program should be put in place as follows:

Week 1 - Fans On
Week 2 - Fans Off
Week 3 - Fans On
Week 4 - Fans Off
etc...

This program should continue for a least 8 weeks after which by monitoring compression run times and the main electric and gas meters, conclusions on the fans actual effect may be drawn by plotting the energy use versus average weekly temperature.

Measure 10 - Lobby Ventilation System

To confirm assumptions made in this report the following run timers should be installed and read weekly:

- supply fan
- washroom exhaust fan
- underseat exhaust fan

In addition the weekly report should record:

- day thermostat setpoint
- night thermostat setpoint
- remarks

4. MONITORING PROGRAM - continued

Measure 11 - Interlock Washroom Exhaust

This measure is included with Measures 6 and 10.

Owners Retrofit

The owners retrofit items result in too small a change to make a demonstratable impact on the main gas and electric meters. A weekly report should be used to:

- indicate cycling of DHW pump
- indicate DHW setpoint
- indicate isolation data of gas fired DHW heater
- indicate chemical treatment tests of evaporative condensor
- indicate date of installation of watt-mizer lamps

Summary

The following meters and reports are required for the monitoring program.

Existing SPC Electric Meter	- read weekly
Existing SPC Gas Meter	- read weekly
Existing ice plant run time meters	- read weekly
1 - New electric meter	- read weekly
9 - New run timers	- read weekly
1 - New BTU meter	- read weekly
Weekly status report on setpoints	
8 week anti-stratification fan test.	

5. CONCLUSIONS & RECOMMENDATIONS

Table 5.1 summarizes the energy conservation opportunities studied in this report, the budgeted capital costs and energy savings, the actual costs and the estimated energy savings.

Energy savings estimated by this report are shown in Table 4.1.

For a total investment of $49,813 the energy index of the building is predicted to be reduced from 61/EKWH/SF/year to 38 EKWH/SF/year achieving an annual saving of $16,855 and a 3.6 year simple payback.

In an ice arena the following measures influence energy use strongly:

- reflective ceiling insulation
- destratification fans
- night setback of equipment
- brine pump controls
- lighting
- heat recovery

For new construction these items should be considered as these items are most economically added at that time.

TABLE 5.1 - NORTH BATTLEFORD CIVIC CENTRE

MEASURE	BUDGETED COST	BUDGETED SAVINGS	ACTUAL COSTS	ANNUAL SAVINGS	PAYBACK PERIOD
2. Insulate steam and condensate piping.	$ 3,500	$ 860	-	$ 2,444	-
3. Replace existing incandescent lighting over seating with fluorescent.	$ 3,500	$ 570	-	$ 369	-
5. Install thermostat controlled valves on lounge radiation.	$ 1,200	$ 250	-	$ 229	-
6. Modify lounge ventilation system.	$ 4,900	$ 520	-	$ 2,229	-
7. Modify arena ventialtion system.	$ 7,000	$1,050	-	$ 555	-
9. Install anti-stratification fans in arena.	$ 6,000	$1,050	-	$ 5,109	-
10. Modify lobby ventilation system.	$ 5,500	$ 780	-	$ 2,235	-
11. Interlock washroom exhaust fan.	$ 300	-	-	-	-
Sub-Total	$31,900	$5,030	$35,082	$13,082	2.7 years
1. Install ice temperature sensor to control brine pump circulation.	$ 1,000	$1,000	0	$ 1,175	immediate
4. Reclaim heat from evaporative condenser to heat domestic hot water.	$ 2,000	$ 220	$1,0831	$ 2,100	5.2 years
8. Replace arena mercury vapour lights with higher efficiency light source.	$ 7,000	$ 700	$15,186	$ 410	37.0 years
Contingency	$13,598	-	-	-	-
TOTAL	$55,493	$6,950	$61,099	$16,855	3.6 years

APPENDIX I

GLOSSARY

GLOSSARY

BTU - British Thermal Unit, quantity of heat

BTUH - BTU's per hour, rate of heat transfer

CFM - Cubic feet per minute, air volume flow rate

CFH - Cubic feet per hour, air volume flow rate

DHW - Domestic hot water

EKWH - Equivalent kilowatt-hours, expresses a natural gas load in terms of kilowatt-hours based on equal energy units

EMWH - Equivalent mega-watt hours, EKWH divided by a 1000

fi & fo - Surface resistance to heat transfer of a horizontal or vertical surface. Subcript "i" refers to an inside surface, still air. Subscript "o" refers to an external surface with moving air blowing over the surface.

GPH - Gallons per hour in US gallons

GPM - Gallons per minute in US gallons

kWhr - Kilowatt-hours. Electrical energy consumption

MWhr - Mega-watt hours. kWhr divided by 1000

KVA - kilo-volt-amps. Measurement of electrical demand. KVA = kWhr/PF

MBTU - Thousands of BTU's

MBH - Thousands of BTUH's

MAT - Mixed air temperature

m^3 - Cubic meters

PF - Power factor

psig - Pounds per square inch gauge, pressure

R-value - Resistance to heat flow

U-value - Heat transfer coefficient of a surface

U-Value is the reverse of R-value

UA - U-value times area of surface

APPENDIX III

FUEL BILLS & HISTORIC FUEL COSTS

Current Utility Rates

Natural Gas

General Service III or IV (effective July 9, 1983)

Basic monthly charge	$ 7.06
Energy charge	12.67¢/m^3

plus 10% estimated rate increase for 1984.

Electricity

General Service IV (effective July 9, 1983)

Minimum monthly charge equal demand charge but not less than 75 KVA.

Demand Charge	$7.65/KVA
Energy Charge	2.14¢/kWhr.

plus municipal surcharge of 10%
plus health and education tax of 5%
plus 10% estimated rate increase for 1984

Marginal Costs

Thus for the purposes of this report the following marginal costs will be used:

Gas - energy charge	13.94¢/m^3
Elec - demand	$9.72/KVA
- energy charge	2.72¢/kWhr.

Electrical Consumption (MWhr)

	1979	1980	1981	1982	1983
Jan	112.8	113.4	109.2		
Feb	94.2	93.6	121.8		
Mar	94.2	104.4	99.6		
Apr	53.4	84.6	66.0		
May	17.4	31.8	25.8		
Jun	20.4	28.8	24.6		
Jul	14.4	29.4	28.8		
Aug	19.8	28.8	115.2		
Sept	94.8	68.4	113.4		
Oct	150.6	166.8	110.4		
Nov	121.8	124.2	106.8		
Dec	132.2	140.4	111.6		
Ann	933.0	1011.6	1033.2		

Note: Electrical consumption includes the swimming pool, parking lot and ball field.

Electrical Demand (KVA)

	1979	1980	1981	1982	1983
Jan	250	270	280		
Feb	220	280	290		
Mar	250	290	290		
Apr	190	270	250		
May	0	120	20		
Jun	250	300	0		
Jul	280	320	320		
Aug	280	320	400		
Sept	430	420	330		
Oct	470	380	380		
Nov	410	350	270		
Dec	280	280	210		
Ann	3310	3600	3040		

Note: Electrical demand includes for swimming pool, parking lot and ball field.

Gas Consumption (m^3)

	1979	1980	1981	1982	1983
Jan	44690	30740	24390		
Feb	39760	21760	27660		
Mar	24200	23720	17520		
Apr	28820	19290	19370		
May	9220	5440	11910		
Jun	2690	2880	1830		
Jul	730	040	920		
Aug	890	840	8360		
Sept	8920	8910	12420		
Oct	18940	18610	17540		
Nov	21400	19360	19170		
Dec	36090	37750	28190		
Ann	236440	189350	189280		